Evaluating location-based services (a position paper)

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ABSTRACT
This position paper outlines a central question at the intersection of geography and human-computer interaction (HCI): how to evaluate location-based services with users? Systems that incorporate spatial information and adapt their behaviour and appearance depending on where users are located, pose specific challenges for evaluation that differ from applications that are not intrinsically linked to spatial concepts. This paper outlines some of these challenges as well as potential approaches to address them and puts them into the wider context of integrating geography and HCI.

Author Keywords
Position paper, location-based services, evaluation

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

General Terms
Human Factors; Design; Measurement.

MOTIVATION
Evaluating systems with users (e.g. for validation and comparison) is an essential activity in Human-Computer Interaction (HCI) research in general and increasingly seen as critical in Geosciences. While it is not always useful to carry out (formal) user studies and not at all stages of development [], in many cases such studies play a central role in evaluating interactive systems. There is a long-running debate about what the best way is to evaluate a particular system with users. Two fundamentally different approaches exist and researchers have argued strongly in favour of (and against) either one: lab-based user studies ("in-the-lab"), which take place in the lab, and field studies ("in-the-field"), which take place in the real world. Both approaches have specific benefits and drawbacks, e.g. in terms of repeatability, realism or cost/effort ratios. A recent survey of publications on mobile HCI during the last decade, revealed a shift from engineering-driven to empirical, evaluation-based research. The authors found that the context of use was not considered much in the early 2000's but by end of the decade, user-centred and context-sensitive approaches have gained popularity. In 2009, lab-based experiments appeared in 49% of the publications surveyed, while field studies accounted for 35%. According to , most of those experiments were conducted in largely controlled settings rather than real usage situations.

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CHI 2013 Workshop GeoHCI, April 27–28, 2013, Paris, France.

OPEN ISSUES REGARDING EVALUATION
Unlike some mobile applications, location-based services (LBS) such as mobile guides, local recommender systems, or geocaching applications inherently and strongly depend on spatial factors in order to function well. Such factors include, for example, the configuration of the environment or the accuracy/precision of the measured position. Consequently, spatial factors need to be explicitly considered (and controlled) during evaluation and thus pose several challenges that still need to be addressed in research. Two examples are briefly discussed below:

Capturing and factoring in spatial aspects
To capture relevant spatial factors in real usage situations, the standard approach is to carry out tests with users in the field. By conducting this type of evaluation, a series of issues can be identified, such as the influence of "urban canyons" on GPS positioning accuracy and its effect on a LBS. However, solely logging the position of test persons during evaluation experiments is not often enough to gather a deep understanding of the users' interactions with the system and the surrounding environment. From this information alone, it remains, for example, unclear whether a user was able to map their environment to the depiction (e.g. a map) on the screen of a mobile device. In addition, specific changes of positioning accuracy and other spatial factors can vary greatly from one participant to the next, thereby potentially influencing the results of a user study.

Spatial fidelity in the lab
Evaluation in the lab offers greater controllability but in case of LBS comes with the difficulty of recreating an adequate level of contextual detail during experimentation. Particularly with respect to spatial aspects of LBS usage, providing the test person with the feeling of presence in a real-world scene can be essential for obtaining valid results. To achieve that, a sufficient number of representative spatial cues should be provided to the test person. Classic lab-based evaluation however often fails to provide those cues, which can result in outcomes that significantly differ from those obtained in the real world. Realistically simulating spatial aspects of real-world environments in the

lab is usually costly and time consuming (e.g. using 3D CAVE systems and virtual models of the world).

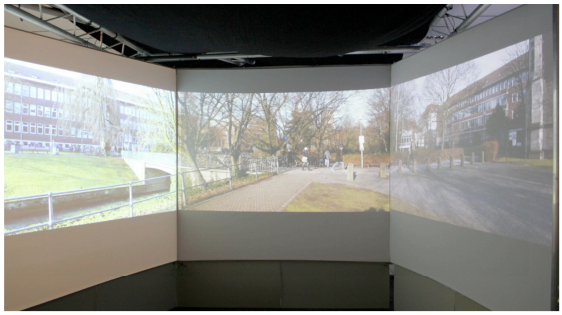

Figure 1. Immersive Video Environment

Figure 2. Snapshot produced by multi-camera recording system.

OWN RESEARCH CONTRIBUTIONS

In the past, we have studied Immersive Video Environments (IVE, see Figure 1) as a means to evaluate mobile applications in the lab (cf. e.g. []). This method has shown significant potential to overcome some typical shortcomings when evaluating LBS in the lab, for example when evaluating applications involving spatial referencing, such as landmark-based navigation systems []. In our previous work, we have also observed behaviours that indicate that participants experience a strong feeling of presence. For example, after only a few minutes inside the IVE, a number of people started to refer to the scenery shown on screen as if they were actually physically located at the location, where the footage was recorded. We are currently extending the IVE in several ways (e.g. by including a GPS-simulator that can also playback GPS signals previously recorded in the field) and are carrying out systematic comparison studies.

In addition, we have developed (and evaluated) a multi-camera recording system for mobile LBS that seamlessly integrates footage from three cameras []. The recording system is very compact in size, and its parts (micro-video recorder, power sources, observation display, head-mounted and distant mini cameras etc.) can fit in a small backpack. It creates much less obstruction to the test person than other alternative recording solutions (e.g. normal video cameras), and offers long recoding duration (6 hours). The resulting footage contains a combined, synchronised view of 3 different cameras and screen capture of the mobile device display (Figure 2). It also contains audio recording of the environment and the test person's and experimenter verbal expressions (e.g. when Think Aloud method is used).

Finally, we have started to investigate the use of the multi-camera recording system inside the IVE, which promises to greatly facilitate the comparison of in-the-field and in-the-lab methods. In addition, this combination allows for a more fine-grained recording and analysis of user behaviour within the video environment.

CONCLUSION

In this position paper, we highlighted evaluation methods as one particular area that sets location-based services and applications apart from other (mobile) systems. Using two examples, we argued that their inherent dependency on spatial concepts poses new challenges in Geosciences and HCI, and that this calls for improved/adapted evaluation methods. We briefly reviewed our own current research in this area, which aims at closing this gap, i.e. by using Immersive Video Environments and multi-camera recording systems. In our opinion, shortcomings, opportunities and future developments in this area could be an interesting topic for discussion at the workshop.

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